English partial translation of Ishida

〔0011〕

In a preferred embodiment of the present invention, said side rail consists of tempered martensitic stainless steel containing from 13 to 22% of Cr. Said spacer expander consists of austenitic stainless steel.

〔0012〕

The present invention is hereinafter explained in detail.

〔0013〕

Only the outer peripheral surface of the side rail used in the inventive combined oil-control ring is subjected to ion-nitriding. In the ion-nitriding method, glow discharging is generated under low vacuum using nitrogen gas alone or gas mixture of nitrogen gas and a minor amount of hydrocarbon-based gas, thereby nitriding or soft nitriding. More specifically, the furnace interior is evacuated to vacuum of for example approximately from 10^{-2} to 10^{-3} Torr. Subsequently, the mixed gas of nitrogen and hydrogen is introduced so as to control the pressure of furnace interior to from 1 to 10 Torr depending upon a treating condition. The furnace body is an anode, while a work piece is a cathode. Glow discharge is created between the anode and the cathode, so that ionized nitrogen is accelerated and hence impinges upon the work piece, which is thus nitrided. In the present invention, only the outer peripheral surface of a side rail can be effectively nitrided by means of employing the ion nitriding, and for example by the methods described in the following examples.

〔0014〕

The advantages of ion-nitriding method is as follows : ① a thick nitriding layer is obtained by a treatment for short period of time ; ② treating temperature is low ; ③ no compound layer is formed on the surface ; ④ coefficient of friction of the ion nitrided layer is lower than that of a layer of the other nitriding methods; ⑤ pre-treating is not necessary because the H^+ and N^+ ions have sputtering function; and, ⑥ no environmental pollution. In a case where the tempered martensitic stainless steel is used as material of a side sail, the nitrided layer is a Fe_4N single layer. The obtained hard layer has high limit value of fatigue strength and improved durability.

〔0015〕

A portion of a spacer expander, which is located between the upper and lower side rails, and which is in contact with at least inner surface of the side rails, is also subjected to nitriding according to the present invention. Nitriding, which is applied to the spacer expander is not limited to the ion-nitriding but various known methods, such as gas nitriding, salt-bath soft nitriding, and gas soft nitriding can be employer. In this

case, only the contact portion of a spacer expander with the side rails may be subjected to nitriding. Alternatively, the total surface of a spacer expander may be subjected to nitriding.

[0017]

Since a side rail is brought into contact with a cylinder bore, its material should have excellent heat resistance and wear resistance. Tempered martensitic stainless steel containing for example from 13 to 22% of Cr, is preferably used. When this tempered martensitic stainless steel is used, an advantage is attained such that the ion nitriding layer is a single Fe_4N layer. A spacer expander imparts tension to the side rails and hence the material of spacer expender is preferably the one having excellent heat resistance, wear resistance, as well as excellent spring property and toughness. For example, austenitic stainless steel is preferred.

[0044]

Example 3

A spacer expander, the surface of which was non-treated, and a spacer expander, the surface of which was salt-bath soft nitrided (tuftriding), were combined with side rails, only the outer peripheral surface of which is ion-nitrided. Two types of the oil-control rings were manufactured.